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ARGUMENTS CONCERNING "WIND TUNNEL TEST STUDIES OF THE TRIM CHARACTERISTICS OF OBJECTS WITH SMALL ASSYMETRIES"

by

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ABSTRACT The experimental methods and results set out in the discussions of original Reference [1] are all correct. However, the mathematical methods and formulae set down in the Reference are not appropriate. This article brings out some different ideas about this and supplies discussion.

KEY TERMS Assymetrical Body, Aerodynamic Effect, Trim Characterisitics, Wind Tunnel Tests, Stability

I. SURFACING PROBLEMS

The original reference [1] discussed methods of testing which were capable of accurately measuring out, in small model wind tunnels, the trim angles associated with objects with very small assymetries. The data set out in the reference as well as the figures and tables are both accurate. However, with regard to the equation for the experimental system which was used being written to be

$$\frac{d^2\vartheta}{dt^2} - \frac{M_z^{\omega_z}}{J}\frac{d\vartheta}{dt} - \frac{M_z^{\alpha}}{J}\vartheta = 0 \quad (1)$$

the so called transition process which one obtains is

$$g_{\Delta\alpha}(t) = \delta_0\left[1 - \frac{e^{-\frac{\xi}{T}t}}{\sqrt{1-\xi^2}}\cos\left(\frac{\sqrt{1-\xi^2}}{T}t - \varphi\right)\right] \quad (2)$$

In this,

$$\varphi = \mathrm{tg}^{-1}\frac{\xi}{\sqrt{1-\xi^2}}$$

δ_0 is the angle of trim. T is the period of vibration. ξ is the damping.

The problem lies in the fact that what equation (1) describes is not the "step leap" process which is spoken of in reference [1]. That process is a change in the direction of roll. Equation (1) does not describe it. What equation (1) describes is a linear second order vibration system. ϑ in equation (1) is measured beginning from the

balance position for the vibration. Because of this, if one wants, in equation (1), to clearly introduce the shape of the trim angle, then, at that time, in the equation, one should have the constant quantity M_0 (the moment of trim forces for a zero angle of attack), changing into a nonhomogenous equation. Because of this, ϑ should be entered into the correction quantity--the angle of trim.

The solutions of equations are initial value problems. In general solutions of ordinary second degree differential equations, they contain two arbitrary constants. From the initial values, these are determined. They are generally selected to be the initial amplitude and initial phase angle. In addition, one puts in the period of vibration and the damping (these are determined from the aerodynamics of models and inertial characteristics). In the solutions of equations, one has included a total of five independent parameters: angle of trim, initial amplitude, initial phase angle, period of vibration, and the damping. However, in (2), one only has four independent parameters: angle of trim (δ_0), phase angle (φ), period of vibration (T), and damping (ξ). Initial amplitude is missing. It cannot be shown from angle of trim in equations like (2).

With regard to what is spoken of in Reference [1] as the "utilization of corrected Newton-Raphson methods", these are not used either to carry out calculations in (2).

II. THE PROCESS OF CALCULATING ANGLES OF TRIM

When models are assymetical, moments of pitch forces for zero angles of attack are not 0. The equation which model experimental systems satisfy should be

$$\frac{d^2\theta}{dt^2}-\frac{M_z^{\omega_z}}{J}\frac{d\theta}{dt}-\frac{M_z^{\alpha}}{J}\theta-\frac{M_0}{J}=0 \tag{3}$$

In this, θ is the instantaneous angle of attack calculated beginning from the direction of air flow. t is the time. J is the moment of inertia. $M_z^{\omega_z}$ is the derivative quantity for the pitch drag moments of force. M_z^{α} is the derivative quantity for moments of pitch force. M_0 is the moment of trim forces for a zero angle of attack. What (3) describes is not a "step or level leap" process. However, it is the vibration process for models before "step leaps" are completed or

after they are finished. The form of the general solution for (3) is

$$\theta = -\vartheta_{CT} + \hat{\vartheta}_0 e^{-\frac{\xi}{T}t} \cos\left(\frac{\sqrt{1-\xi^2}}{T}t - \varphi_0\right) \quad (4)$$

After a series of numerical value points for $\theta \sim t$ are measured out in experiments, it is necessary to identify, in (4), five parameters: ϑ_{CT}, ξ, T, θ_0, and φ_0. We used four types of methods in order to identify them. Corrected or ammended Newton-Raphson methods are one type among these. It is necessary to clearly point out that numerical values for angles of trim are one half of the difference in results obtained from two iterations of calculations, before and after step or level leaps.

In the process of measuring data, when air flow angles of deviation give rise to changes, the value of ϑ_{CT} will be influenced by it. However, there are only a small number--a few--tests which show the appearance of this type of situation. In the vast majority of situations, after vibration periods are adequately lengthened, models all are placed into minutely small vibrations in the vicinity of the angles of trim. Because of this, it is only necessary to carry out simple graphing out of charts or average amplitude calculations and it is then possible to obtain relatively accurate values for angles of trim.

REFERENCES

[1] Huang Xingzhong; "Wind Tunnel Research on Trim Characteristics of Objects with Small Assymetries", Acta Astronautica Sinica, No.2, 1987, pp 68-75

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